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ABSTRACT

The paper reviews research dealing with spatial cognitive ability differences in gifted children and cites implications for reading instruction of gifted readers. A study is detailed which found (1) different spatial profiles for 62 gifted middle students, and (2) that Ss had either three-dimensional transformational excellence or outstanding two-dimensional recognition ability, but not both. Case studies are presented to illustrate how "severely gifted readers" may be stifled in their creativity by traditional literature approaches, and how spatially gifted readers frequently intertwine spatial, mathematical, and linguistic ideas. Suggestions for teaching include broadening the curriculum to find instructional tasks compatible with student interests. A nine-page list of reading selections in science fiction chosen by, and intended for, spatially gifted readers is preceded by a brief consideration of the importance of mental imagery. (CL)

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SPATIAL ABILITY OF GIFTED READERS:

Suggestions for Teaching

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SPATIAL ABILITY OF GIFTED READERS:
Suggestions for Teaching

This presentation will cover three general areas:

We will start with a look at current research
because
it is the most important issue
it is the most laborous issue

We will then discuss case studies and personal observations
because
they may be funny or sad
you may indentify your own experience with them
they may be the most remembered information
they help clarify issues in the research

We will end with lesson ideas and reading lists
because
they are the most useful

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SPATIAL ABILITY OF GIFTED READERS:
Suggestions for Teaching

by
Meredith B. Olson

I must confess that I did not choose the title of this presentation but it was constructed for me by others. Definitional problems in the title intrigue me. Are we to deal with those "gifted" who read as opposed to those "gifted" who do not read? Are we to discuss individuals whose reading ability is "gifted" in some way? In order to avoid these definitional problems I have chosen to discuss my research on "spatial ability of the gifted" first, and then comment on implications of this research for reading instruction of "gifted readers". The terms "spatial ability", "gifted", and "gifted readers" will be defined as the discussion progresses.

SPATIAL COGNITIVE ABILITY DIFFERENCES:
A redefinition of giftedness

The Subjects

The study, which examined the "factor-specific" component parts of spatial ability, began in 1979. This study examined an intact population of "gifted" students enrolled in Seattle Country Day School in Seattle, Washington. "Gifted" middle school students (primarily grades four through eight) constituted the population under consideration. The WISC I.Q. test had been administered to all of the students in this study as part of the entrance examination. All of the 62 middle school students were involved in this study. They all scored above 125 on the WISC, with a mean score for the group of 137.

Seattle Country Day School had, due to involvement in research on cognitive attributes of the "gifted" since 1975, been particularly receptive to the admission of students with high Block Design scores on the WISC I.Q. test. This WISC subscore had appeared to the staff of the school to have some predictive value in identifying creative mathematics students. (Beckman, 1981) The sample population achieved scores in the upper half of the possible score range of the Block Design subtest of the WISC I.Q. test. Approximately half of the subjects scored between 16 and 19 on the Block Design subtest, while the other half scored from 12 to 15. The score range of the Block Design subtest is 1 - 19 with average ability being represented by a score of 10. Thus the "high ability" range from 12 to 19 was represented throughout its continuum by this sample population.

The students involved in this study were plainly not a representative or random sample of all "gifted" students. However, since this study was focused on "spatial" modes of thinking, these students seemed to be particularly suitable.

The Tests

The design of this study called for the identification of students with similar profiles on factor-specific components of spatial ability. A search of the literature revealed batteries of "spatial" tests in civil service exams, military service exams, and differential aptitude exams. In previous exploratory research on other populations of "gifted" students, the Iowa Cognitive Ability test battery and the Structure of the Intellect (SOI) had been used. Findings of these projects led to the theoretical expectation that certain types of tests might be more applicable

to this research project than others would be. Some tests asked for quick recognition of an object which matched a given object. Other tests required that the subject rotate images mentally to determine the label on the hidden side of an object. Still others asked for assembling objects from the printed component parts. All tests consisted of typewritten words or black and white line drawings.

Some test authors claimed that their tests were discrete or "factor pure" when examined using various statistical analyses. Validity assertions of test writers were used as a general guide to test selection, however, it was felt that these "gifted" students might use thought strategies which would alter the definition of "factors". Several tests designed to examine a single "factor" seemed to elicit quite different response patterns in various "gifted" individuals. The purpose of this study was not to isolate separate "factors" unique to "gifted" minds, but simply to determine whether students who had exhibited similar classroom behavior would achieve similar profiles on an assemblage of logical and spatial tests.

A generous supply of military and civil service cognitive ability exams was found in a school surplus storehouse. From this assemblage of available tests an array of likely looking tests was gathered.

In order to establish criteria for grouping students (using test profiles), which could be replicated by other researchers, no "teacher made" tests were considered for use. Components of I.Q. tests which had to be administered by a psychologist were

also not considered for this study. Only tests which were designed to be administered to groups, which had been used in other applications, and which might be available to other researchers, were used. All of the cognitive abilities tests considered for this study had been normed on other populations and had scoring procedures well defined.

The tests had been designed with consistency (form-associated reliability) in mind and had been extensively tested for this property. The educational testing service included data showing form-associated reliability coefficients of .7, .8, or .9 between the two half-tests of each test derived from several sample populations.

Simplified aptitude factors used as descriptors by the test designers are shown in table 1.

Table 1

TEST	CONTENT
Hidden Figures	similar to embedded figure
Concealed Words	out-of-focus pictures
Cube Comparison	spatial orientation - rotation 3-D
Card Rotation	spatial orientation - rotation 2-D
Hidden Patterns	embedded "man-like" figure
Nonsense Syllogisms	logical reasoning -nonsensical
Form Board	spatial restructuring- component parts
Hidden Words	four letter words in random letter lines
Paper Folding	spatial restructuring-fold & punch
Deciphering Language	transitive reasoning-symbolic language
Inference	if-then conclusions
Copying	embedded - copy pattern on dots
letter sets	find a rule to relate 4 letters
Surface Development	spatial restructuring, fold-up
Gestalt Completion	out-of-focus pictures
Diagram Relations	Venn diagrams, transitive reasoning
Calendar	complex set of sequential directions
Shape Memory	visual memory for four minutes
Locations	find a rule to relate dot-dash arrays
Identical Pictures	perceptual speed test-match items
Following Directions	complex set of sequential directions

Test Administration

The order of test administration was determined randomly by selection from the shuffled pile of tests. Recognizing the limited attention span of children, ten to fifteen minutes at the start of each science period were devoted to the testing. Test directions were read to the whole class at the start of the testing period. Sample test items were presented on the overhead projector and correct answers were pointed out to the class. This was done to help students understand the test directions which had been composed for adults. Students were given a countdown until the starting moment. Papers were then turned over and the time allotment which had been established for adults was followed. The tests were hand scored using scoring procedures accompanying the tests. Scores were not revealed until the end of the term in an effort to reduce practice affects in score achievement on the second test half.

The Partitioning

Provision had been made in the design of one of the research projects for obtaining information which might be used to group the cognitive ability scores of this sample population according to differences in their behavior in the math-science room. The investigator had noticed that "gifted" populations in Idaho and South Carolina both contained some students with interest in three-dimensional puzzles. For the purpose of this study, "attention-focus" on such puzzles was correlated with cognitive ability scores in the following manner.

Students had been observed for the first fifty days of the school year as they entered the math-science classroom. Each day

three puzzles had been placed around the room on top of book cases, on shelves, and on various ledges. The puzzles used were: The Brain, Looney Loop, Rubic's Cube, Chinese Rings, Frypan Maze, Whipit, Pyraminx, The Snake, and the Missing Link. Although middle school age students typically entered the classroom in a rather disorderly manner, certain consistencies were noticed in the intensity with which students sought to obtain the 3-dimensional puzzles. Differences in interest displayed in working toward a solution of puzzles were recorded by an observer.

Type-A students. Students were categorized as Type A if they were never observed (by the rater) to attempt to solve a manipulatory puzzle. Usually, these students were observed to enter the room in conversation with another Type-A student. The conversation typically focused on social interaction of real individuals or of TV characters. Conversation frequently was about clothing style or rock music. Occasionally the conversation was about school work or school affairs. These students normally entered the room conversing, strolled to their regular seats, sat down, opened their notebooks, and looked at the teacher to ascertain when class would begin. When asked about student relations in the room, they were usually able to discuss who was "in love" with whom, and which students were "in a bad mood" that day. They seemed to have a sensitivity to the social setting around them even while occupied in conversation. Further questioning indicated that, in general, they failed to notice the presence of the puzzles.

Type-B students. Another type of behavior profile,

categorized as Type-B, seemed (to the observers) to be much more focused on the physical environment. These students appeared to notice the new puzzles positioned around the room as soon as they entered and were quickly attracted to them. These students often quarrelled over whose turn it was to manipulate the object. They typically did not speak while manipulating the puzzle. They seemed to prize the experience of figuring out the puzzle themselves and complained if anyone told them how to work it. They were unable to recall social interactions which had been going on in the room while they were intently working the puzzle. They were unprepared for the start of class and seemed surprised that the time had arrived. They did not read "teacher messages" well. They failed to notice the teacher waiting for them to settle down. When the teacher verbally reminded them that it was time for class to start, they were cooperative and well behaved. When not concentrating on the solution to a puzzle, conversation was most frequently with another puzzle oriented student. Conversation centered around science fiction stories about space exploration, computers, and their own participation in sports.

Clearly, this type of behavioral record is subject to unconscious observer rating biases and to students "showing off" for the observer, however over the fifty day period certain behavioral trends remained constant. Even though inaccuracies in observer ratings were expected as part of this subjective procedure, it was anticipated that these approximate methods of grouping students according to predominant behavioral patterns might draw our attention to tests on which a given type of child excelled.

In addition to the categorization of "attention-focus", a second project which independently attempted to homogeneously group these "gifted" individuals, was undertaken. Students were divided into "types" on the basis of their behavior in mathematics enrichment activity. Students were presented with open-ended problems of the type published in Martin Gardner's mathematics column in Scientific American. Three lessons were used to catalogue student responses. These were Magic Squares, Pascal's Triangle, and Color Cubes. Those students who made original discoveries were classified as Type-R. Those students who failed to make original discoveries were classified as Type-S. Table 2 shows that Type-R members all came from Type-B students, and that Type-S students came from both Type-A and Type-B.

Table 2

PARTITIONING SCORES OF 59 "GIFTED" STUDENTS
INTO
THREE "ATTENTION-FOCUS","MATH-DISCOVERY" TYPES OF STUDENTS

TYPE A	TYPE B	
TYPE S		TYPE R
Type #1	Type #2	Type #3
22 subjects	24 subjects	13 subjects
12 females 10 males	4 females 20 males	2 females 11 males
0 grade 3 3 grade 4 6 grade 5 3 grade 6 8 grade 7 2 grade 8	2 grade 3 4 grade 4 10 grade 5 7 grade 6 1 grade 7 0 grade 8	1 grade 3 2 grade 4 4 grade 5 2 grade 6 4 grade 7 0 grade 8

Partitioning scores into these three groups of students presented a very different picture of spatial ability from that produced by the sample population as a whole. Type 1 students: the conscientious, conforming student showed strengths in two-dimensional spatial recognition. Type 3 students: the creative non-conformists revealed a superb ability in 3-dimensional spatial transformational thought. Table 3 shows the raw scores achieved by groups within the sample population.

Table 3

TABLE OF MEAN RAW SCORES

FOR 59 GROUPED MEMBERS OF THE SAMPLE POPULATION AND FOR THREE "ATTENTION-FOCUS","MATH-DISCOVERY" TYPES OF STUDENTS

TEST	Mean#1	Mean#2	Mean#3	59 Student Sample Mean
Hidden Figures	8.29	5.97	8.28	7.35
Concealed Words	13.45	11.79	13.23	12.72
Cube Comparison	9.18	11.00	14.30	11.05
Card Rotation	81.40	87.12	92.69	86.22
Hidden Patterns	149.77	136.50	137.15	141.59
Nonsense syllogisms	3.63	5.58	14.46	6.71
Form Board	93.63	95.08	127.23	101.52
Hidden Words	54.22	47.40	50.76	50.72
Paper Folding	8.52	9.62	12.88	9.93
Deciphering Language	11.19	7.91	12.48	10.14
Inference	9.75	9.77	11.42	10.12
Copying	25.36	23.95	26.76	25.10
Letter Sets	16.56	15.93	19.73	17.00
Surface Development	18.29	20.88	32.42	22.90
Gestalt Completion	9.86	10.25	9.15	9.86
Diagram Relations	14.21	15.73	18.03	15.67
Calendar	10.52	9.65	12.86	10.68
Shape Memory	17.22	18.16	17.38	17.64
Locations	8.47	8.72	10.55	9.03
Identical Pictures	65.57	54.71	56.30	59.11
Following Directions	9.40	9.35	12.96	10.11

Raw score values varied greatly according to the design of the various tests. Some common referent for comparing the variation of scores between groups and between tests was needed.

Calculating the standard deviations for the grouped sample population from their raw scores, and listing the means of each of the above defined groups in deviation scores, produced the comparison data shown in table 4.

Table 4

TABLE OF "GIFTED" SAMPLE POPULATION Z--SCORES

FOR 59 GROUPED MEMBERS OF THE SAMPLE POPULATION
AND FOR
THREE "ATTENTION-FOCUS","MATH-DISCOVERY" TYPES OF STUDENTS

TEST	Mean#1	Mean#2	Mean#3	59 Student Sample Mean
Hidden Figures	+.22	-.30	+.22	+.006
Concealed Words	+.14	-.13	+.10	+.02
Cube Comparison	-.18	+.03	+.43	+.04
Card Rotation	-.10	+.12	+.34	+.08
Hidden Patterns	+.20	-.12	-.11	-.009
Nonsense Syllogisms	-.46	-.13	+1.19	+.03
Form Board	-.20	-.16	+.72	+.01
Hidden Words	+.19	-.21	-.01	-.01
Paper Folding	-.26	-.002	+.76	+.06
Deciphering Language	+.23	-.40	+.48	+.03
Inference	-.07	-.07	+.28	+.004
Copying	+.06	-.11	+.24	+.02
letter Sets	-.06	-.19	+.54	+.01
Surface Development	-.30	-.11	+.85	+.02
Gestalt Completion	-.002	+.10	-.10	-.001
Diagram Relations	-.26	+.003	+.40	-.007
Calendar	-.02	-.21	+.46	+.006
Shape Memory	-.002	+.13	+.02	+.05
Locations	-.10	-.05	+.36	+.01
Identical Pictures	+.50	-.34	-.20	+.03
Following Directions	-.11	-.12	+.52	+.02

A review of table 4 indicates that the mean scores of Type #3 students were above the means of the 59 member sample population on most of the tests, while Type #1 and Type #2 were below the sample population means on most of the tests.

Conversion of these scores to young-adult z-scores allowed a comparison of these "gifted" middle school students with normal young adults, as shown in table 5.

Table 5

TABLE OF STUDENT MEAN SCORES CONVERTED TO ADULT Z-SCORES

FOR 59 GROUPED MEMBERS OF THE SAMPLE POPULATION AND FOR THREE "ATTENTION-FOCUS","MATH-DISCOVERY" TYPES OF STUDENTS

TEST	Mean#1	Mean#2	Mean#3	59 Student Sample Mean
Hidden Figures	-.95	-1.28	-.95	-1.09
Concealed Words	-1.42	-1.70	-1.46	-1.54
Cube Comparison	-1.60	-1.37	-.96	-1.36
Card Rotation	-.13	-.01	+.09	-.03
Hidden Patterns	+.20	-.14	-.12	-.01
Nonsense Syllogisms	-2.65	-2.10	+.11	-1.82
Form Board	-.76	-.72	+.08	-.56
Hidden Words	+.01	-.40	-.20	-.20
Paper Folding	-.86	-.59	+.22	-.51
Deciphering Language	+.79	-.29	+1.22	+.44
Inference	-.56	-.55	-.14	-.46
Copying	+.07	-.22	+.08	-.09
letter Sets	-.28	-.41	+.34	-.19
Surface Development	-1.55	-1.36	-.39	-1.22
Gestalt Completion	-1.03	-.93	-1.21	-1.03
Diagram Relations	+.44	+.74	+1.20	+.73
Calendar	+.45	+.22	+1.06	+.49
Shape Memory	-1.04	-.80	-1.00	-.93
Locations	-.25	-.19	+.26	-.10
Identical Pictures	+.95	-.12	+.03	-.31
Following Directions	-.14	-.16	+.67	+.02

Table 5 above shows that although the 59-student mean was -1.82 adult standard deviations, the mean of Type #3 students was above the adult mean on this test. The mean of Type #3 students was 2.76 standard deviations above the mean of Type #1 students. Nonsense Syllogisms was thus identified as a test whose score could be useful in discriminating between "physical-world

attention-focus", "mathematical-discovery prone" students and "socially-focused", "non-discovery prone" students.

On the other hand, Identical Pictures showed a mean for Type #1 of .92 standard deviations above the mean of Type #3. "Socially-focused", "non-discovery" students registered their greatest mean score difference over other students on this test.

Two other tests showed a difference in mean values between Type #1 and Type #3 students of more than a full standard deviation. These tests were: Surface Development and Paper folding.

The four largest mean differences between Type #1 and Type #3 students are listed in table 6.

Table 6

THE FOUR LARGEST DIFFERENCES IN MEAN SCORES

USING YOUNG ADULT STANDARD DEVIATION SCORES

High Scoring Type	Test	SUBTRACTED SCORE VALUES Type #1-#3	Type #1-#2	Type #2-#3
Type #1...	Identical Pictures.....	.92	1.07	.15
Type #2....	Nonsense Syllogisms.....	2.76	.55	2.21
Type #2..	Surface Development.....	1.16	.19	.97
Type #2....	Paper Folding.....	1.08	.27	.81

The Discovery of Different Spatial Profiles

In this manner it was discovered that three dimensional spatial transformations are cognitively very different from two dimensional tasks. The "gifted" sample population as a whole was

above the adult mean on tests requiring transitive, sequential reasoning; complex sequential rule following; and perceptual scanning speed. Had the sample population not been partitioned, we would have concluded that "gifted" students are best characterized by rapid sequential thought and that abilities tapped by other tests in the assemblage were not strongly representative of "giftedness". The naturalistic studies of this population allowed the partitioning of students into three types (discussed above) which shed an entirely different light on the modes of thinking of "gifted" students.

"Socially-oriented", "non-discovery prone" "gifted" students (type #1) were above the "gifted" sample mean on tests shown in table 7.

Table 7

TYPE # 1 STUDENT'S - HIGH SCORES

Hidden Figures	similar to embedded figures
Concealed Words	out-of-focus pictures
Hidden Patterns	embedded "man-like" figure
Hidden words	four letter words in random lines
Deciphering language	transitive reasoning
Copying	embedded - copy pattern on dots
Identical Pictures	perceptual speed test - match

This group of tests may be summarized as encompassing recognition and sequential direction following skills. The scores produced by Type #1 students were nearly identical in thought process with high scores produced in the total "gifted" sample population overview. It is reasonable to believe that students who excell in these skills should thrive using "advance organizer" methodologies of expositional instruction.

The "physical-world", "discovery-prone" "gifted" students were above the student mean on many of the tests. Table 8 shows scores grouped by their distance above the "gifted" sample population mean.

Table 8

TYPE #3 STUDENT'S HIGH SCORES

ABOVE +1.0 STANDARD DEVIATIONS	
Nonsense Syllogisms	logical reasoning-nonsensical
ABOVE +.8 STANDARD DEVIATIONS	
Surface Development	spatial restructuring, fold-up
ABOVE +.7 STANDARD DEVIATIONS	
Form Board	spatial restructuring- component parts
Paper Folding	spatial restructuring
ABOVE +.5 STANDARD DEVIATIONS	
Letter Sets	find a rule to relate four letters
Following Directions	complex set of sequential directions
ABOVE +.4 STANDARD DEVIATIONS	
Cube Comparison	spatial orientation - rotation 3-D
Deciphering Language	transitive reasoning-symbolic language
Diagram Relations	Venn diagrams - transitive reasoning
Calendar	complex set of sequential directions
ABOVE +.3 STANDARD DEVIATIONS	
Card Rotation	spatial orientation - rotation 2-D
Locations	find a rule to relate dot-dash arrays

This group of tests may be summarized as encompassing spatial restructuring, rule discovery, and logical reasoning. This sub-population of "gifted" students was not identified by the original sample population overview.

A thought process of particular interest is the necessity of ignoring standard word meanings in the logical reasoning required in Nonsense Syllogisms. Student comments suggested that "socially-focused" (type #1) students had difficulty disregarding the standard meaning attached to words. Type #1 students

appeared to use words as meanings, while type #3 students were able to reason with words as "objects".

The "physical-world focused", "non-discovery prone" students had mean scores above the "gifted" sample population on tests shown in table 9.

Table 9

TYPE #2 STUDENT'S HIGH SCORES

Cube Comparison	spatial orientation - rotation 3-D
Card Rotation	spatial orientation - rotation 2-D
Gestalt Completion	out-of-focus pictures
Diagram Relations	Venn diagrams - transitive reasoning
Shape Memory	visual memory for four minutes

This group of tests may be summarized as encompassing spatial orientation but not spatial restructuring. This "gifted" sub-population was not identified in the original overview.

Subtracting deviation scores between groups one and three revealed the sharpest contrasts in scores on which any groups differed, as shown in tables 10 and 11.

Table 10

TESTS ON WHICH
TYPE #1 SCORED SUBSTANTIALLY ABOVE TYPE #3

Hidden Patterns	embedded "man-like" figure
Identical Pictures	perceptual speed test-match items

This pair of tests required rapid recognition of pre-organized information.

Table 11

TESTS ON WHICH
TYPE #3 SCORED SUBSTANTIALLY ABOVE TYPE #1

Nonsense Syllogisms	logical reasoning -nonsensical
Form Board	spatial restructuring- component parts
Paper Folding	spatial restructuring-fold & punch
Surface Development	spatial restructuring, fold-up

This group of tests required spatial restructuring and reasoning using words as if they were objects.

Research Conclusions

Whereas previous research had frequently found contradictory data regarding spatial ability in various groups of gifted students, we now conclude that "spatial" ability is not a single entity. Individuals in this study have either three-dimensional transformational excellence or outstanding two-dimensional recognition ability - but not both. "Gifted" individuals seem to have one or the other preferred mode of thinking.

What are the implicatons of these two modes of thinking for reading instruction? Do students with these two types of spatial ability abstract different information from reading selections? It has been said that you learn what you want to learn. Do both types of students want to learn about literature from the same perspective?

Our research indicates that reading teachers are commonly strong in two-dimensional spatial recognition skills. They like to read fast and well. One would expect them to understand and be able to motivate students with abilities similar to their own. But what of the "other" type of "gifted" student? Should the same curriculum be applied to both types of students?

DEFINITION OF GIFTED READERS
From Infancy to Adulthood

What is the definition of a "gifted reader?" Are "gifted readers" found in both categories of "spatial ability?" Do the majority cluster around one mode of "spatial" thought? Are teachers able to detect differences in "spatial" ability among their "gifted readers?" Do literature assignments attract interest and enthusiasm from students with differing "spatial" abilities?

Our research indicates that literature assignments favor one mode of "spatial" thought and that teachers are largely unaware of the existence of the other type of student in their class. The following discussion will show that we fail to detect certain types of "severly gifted readers" and will make suggestions of ways to address the problem.

We Identify Gifted Readers In Grades 1 and 12

"Gifted readers" have often been defined as "children who, upon entering first grade, are reading substantially above grade level or who possess the ability to make rapid progress in reading when given proper instruction "(Bonds & Bonds, 1980). In fact it has been claimed that most "gifted" children know their alphabet by sight and read many words by the age of four (Price, 1976). "Gifted" pupils usually have acquired an extensive vocabulary and they generalize the use of these words to new situations. They usually have discovered phonics elements on their own and use context and pictures as cues in the comprehension of what is read (Witty, 1971, Trezise, 1977). To many educators reading represents the essence of "gifted"

behavior (Gallagher, 1975; Labuda, 1974; Hilton,1974; Trezise, 1978; Witty, 1941).

Several reading assessment inventories are available to teachers of young children. Informal Reading Inventories by Betts (1941) , Silvaroli (1973), and Such-Allred (1971) provide information concerning word recognition ability, motivation and stamina, attentiveness and independence, and frustration level. Although concern over the inadequacy of early identification procedures has been expressed by numerous educators, early reading in the first grade remains one of the most easily recognizable benchmarks of "gifted readers."

Twelve years later it is again reasonably easy to identify "gifted readers." The wide administration of the Scholastic Aptitude Test for use in college entrance applications provides a uniform measure of comparative ability. Since the SAT multiplies the score on the English language section of the test by two and adds this to the score achieved on the math section, it is very unlikely that a National Merit Scholar will fail to be a "gifted reader."

But what about the years in-between? Is there a one-to-one correspondence between first grade and twelfth grade? Do students who appear "gifted" in the first grade still look "gifted" in the twelfth grade? Have some lost their "giftedness"? Have some suddenly developed "gifts"?

Severely Gifted Readers Go Unnoticed In The Regular Classroom.

Many educators are of the opinion that children are driven toward average behavior by the structure of the school

system (Malone, 1974). There seems to be an implicit belief that most children identified as "gifted readers" have the potential to be creative, however, at the same time there is widespread concern over the way creativity declines as a child progresses through school (Wikstrom, 1976). Is this decline real or is it an artifact of the assignments we give?

At least one well known educator of the "gifted" (Torrance, 1965) has asserted that overtraining in critical reading or reading for comprehension may limit creative behavior. If one uses books as starting points for thoughts which go beyond one's own direct experience, then it is likely that excessive analysis of the reading material will get in the way of new idea creation.

At all ages "gifted readers" exhibit interest, persistence, and motivation for reading (Bonds & Bonds, 1980), however this may not be demonstrated in the classroom setting. Teachers expect readers defined as "gifted" to perform analysis, synthesis, and evaluation of literature materials assigned. Certain "gifted" students may prefer to read for entertainment, enrichment, satisfaction and fulfillment (Ransburg, 1981) rather than for instruction. The "spatially gifted" frequently do not reveal their non-assigned reading activities to the reading teacher.

Later in this presentation we will discuss how the tasks required by literature teachers cause at least one category of "gifted readers" to avoid much demonstration of their abilities in the school setting. Case study research has revealed a strong under-cover reading network among certain "severely gifted readers." What drives their interests "underground?"

PROBLEMS OF THE GIFTED READER WHO IS ALSO SPATIALLY GIFTED

Case Studies

An Essay

Einstein wrote about "Special and General Relativity." Isaacman wrote about "Special and General Creativity." His essay began with:

> The astute student of physics, having up to this point been introduced to such idealistic sounding laws as "Conservation of Energy" and "Conservation of Matter" should, in preparation for future work in a scientific field, become acquainted with one of the harsher, though more immediately practical, laws of the natural and academic worlds. The law is "Conservation of Status," or, as it is also known, "Publish or Perish."

The essay begins innocently enough to intrigue literature teachers. It points out that Einstein achieved immortality by writing exhaustively about only two highly theoretical and largely impractical theories. So far, so good. Isaacman then goes on to derive mathematical equations for "intellectual inertia" (which he calls Sluggishness) which is measured in units of "Lethar Gravities," (or Lethar g's) named after Edward Lethar - who it is noted, died in obscurity because of a failure to get any work published. The essay derives an equation for "creative acceleration (words per second) which turns out to be inversely proportional to Sluggishness. Not satisfied with that, the essay continues to examine the limit (mathematical limit, that is) at which the velocity of words remains constant. Perhaps we need to excerpt a bit more of the paper to provide a general idea of its' style and content.

It is clear that in order to produce a creative acceleration, there must be some force acting upon the Sluggishness of the writer. The resultant acceleration will be proportional to this force, though inversely proportional to the Sluggishness. Thus:

(2.1) $$a = F/S \quad \text{or} \quad F = Sa$$

Acceleration is measured in "words per second".

But just what is this force? Clearly, it must be external in origin, since in general, all internal forces cancel by symmetry. The standard representation of a force, as when dealing with fluids, is the product of a pressure and an area. In this instance, the pressure is the external creative pressure upon the writer, measured in the case of a student writer in "grade penalty per day late," and for the case of a freelance writer, in "cents per word paid." Area is measured in "pages," or square pages. (NOTE: The international standard "square page" is defined as being 8 1/2" x 11", which actually isn't square at all)

Example: If a student laboring under one Standard Earth Sluggishness (9.8 Lethar g's) has a ten-page paper due with the teacher imposing a penalty of half a grade per day late, what is his creative acceleration? Solution: External Force = pressure x area

$$F = PA$$

Creative acceleration $a = F/S$

$$= PA/S$$

$$= (.5)(10)/9.8 \text{ words/sec}^2$$

Hence the student will write with an acceleration of approximately 0.51 words per second squared. Let us examine this result. According to the rules of kinematics, velocity $v = v_o + at$,

that is, with an initial velocity of zero, the velocity at time t of a body undergoing an acceleration a will be equal to the product of that acceleration and the time the body has been undergoing it. Therefore, at an acceleration of 0.51 w/sec squared, after a period of only 100 seconds, or one and two-thirds minutes, the student would be writing at a rate of 51 words per second. This is, charitably speaking, highly unlikely for a human being. What has gone wrong?

CREATIVITY RELATIVITY: What has "gone wrong" in the previous example is that we assumed all quantities to be static and unchanging. In fact, this is not the case. Because of the necessity of having to do more work as one writes faster and faster, the Sluggishness of the writer increases with velocity, according to the following relation:

(3.1) $$S = \frac{S_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Here, S represents the Sluggishness at a given velocity v, while S_o is the "rest" Sluggishness. Note that as the velocity approaches the value c, the quantity v / c approaches unity, causing the denominator to go to zero, thereby making S infinite. But as S approaches infinity, the creative acceleration (according to equation 2.1) will decrease to zero, and the velocity will thus remain constant for any length of time after that.

From the above, it can be seen that the value of c is thus the ultimate velocity of the writer, since creative acceleration must cease when it is attained. It is therefore referred to as the "Velocity of Write."

The paper continues for several more pages discussing momentum and energy, friction, and distraction in terms of six more derived

equations. The paper ends with a section entitled CONCLUSION.

> We have concluded our introduction to the fundamental principles underlying creative writing. It is hoped that, equipped with this information, the student of Physics or English will be able to transcend mere knowledge of his field, and proceed to a higher state of understanding in which he can convince others that he knows what he is talking about regardless of whether that is actually the case. By mastering Creativity, the ratio of constructive action to abstruse thought can be increased to its theoretical limit, toward the ultimate goal of writing endlessly on a new idea which itself took only a few seconds to think out. Therein lies the secret of success in the academic community.

What literature teacher would be willing to score a paper like that? Clearly this essay contains structural analysis of both literature and of mathematics. This writer is concerned with previously undiscovered relationships between the style of mathematical proof and the creative interplay found in literary works. Using the "conventional language" of mathematical discussions, the author has interposed the subject matter of literary creativity. Intentional alterations in foreground and background are obvious. We see a mind at work which is equally comfortable with literary style, humor (derived from double meanings and homonyms from the world of physics) and mathematics. This author is so comfortable with multiple modes of thinking that he is able to play with them and intertwine them creatively. Unfortunately most literature teachers are not able to read the mathematics, let alone recognize the way the equations parallel (and lampoon) famous equations used in physics. A student of this type quickly learns that the world of literary composition is restricted to a very narrow channel of thought (from his view). This type of student will usually conform to the demands of a literature teacher for most of his high school career in

order to make it through the "system." Although the compositional skills demonstrated in this essay are exactly those most highly prized by English teachers, this type of humorous critique of literary style is normally revealed only to kindred spirits outside of the school setting.

Two Young Men

Two young men I once knew developed the habit of going off together on Saturdays. One was a sophomore in high school at this time, the other was a junior. They would leave about 9 a.m. and return to their homes in the evening. Being good students and responsible individuals, no one paid much attention to where they went or what they were doing. Their activities were eventually revealed in the course of casual conversation. It seems that they had developed a game which they called "Random Library." They would go to the library of the local university to play. As they explained it, their major problem was developing a method for generating truly "random" numbers. This often took them most of the morning. After they were satisfied with their set of "random" numbers, they looked up the books registered under these numbers in the large card catalogue. After collecting all of the books identified in this way, they spent the rest of the day finding relationships between and among the selections concerning philosophical, mathematical, and literary ideas. They examined interplays of literary background and foreground, the ways in which traditional grammatical structures of conventional language had been intentionally violated by authors, and the methods by which such creative

violations could be produced by intersecting one randomly chosen work with another. They were examining not only what the passages meant but how language operates. This was direct inquiry into structural analysis of literary composition. Mathematical operations were as acceptable as linguistic operations. Rhyme schemes and linguistic flow, time and continuity, climax and resolution, sequence, series and the mathematical concept of limits all were woven into the entertainment of the day.

Very few people ever found out about this activity. It was done for humor and intellectual satisfaction. None of it was written down, of course. None of their school teachers ever learned of this activity. Both young men became National Merit Scholars, and both are currently in PhD programs in physics at different universities.

The First Young Man

The first young man progressed through his high school career in literature with "straight A" grades, but without sharing his personal interests. He taught himself to type and to spell in a moderate way. He frequently commented on his great enjoyment of his year of philosophy. Looking through his compositions in his school papers produced the following list.

A look at Pride and Prejudice" in terms of its title.

Alice in Wonderland: a commentary on the way Victorian society stifles people's minds.

"Only he who does what is right acts freely." Jaspers
An argument against Plato's definition of freedom to do wrong.

"Happiness (your own and others)is not the end at which the good man aims; rather it is the reward which he receives."

On Plato's Theory of Education: questioning the absolute good

On Time: (Augustine sees the world as a phenomena of the present. I see the world as a four dimensional continuum through which we move.)

Descartes and absolute truth (problems with the definition of existance)

"What then shall I conclude from all this evidence?"
(On Descartes)

The Nature of Physical Reality

Communication is What Makes Man Human. (On Jaspers)
(Communication is essentially a sharing of experience and if people don't have common experience they can't communicate)

Many of these papers were over twenty pages in length. All were well documented with quotations and footnotes. This student obviously had strong language arts skills, and yet he frequently was at loggerheads with his language arts teacher. He and his friends could be overheard making disparaging comments about literature courses as they worked at the computer terminals of the school. The following quotation from one of his essays points out the problem.

> I have read the first three and one-half chapters of "A Clockwork Orange" and don't like it. I see no point in reading about sex, violence, and other things of low morality because I believe that I am what I get from my environment.
>
> I can see two grounds on which you could base an argument for having me read this book. One is that this book portrays some of the conditions that have happened in England, that are happening now, and that may happen in the future, and that I should not blind myself to them. I agree, but I would prefer to find out about them from facts - not fiction based on facts. The other point is that many people read and like this type of stuff and that I should read it so that I can

find a common ground with them. After all, I am going to live with them for the rest of my life. This is true but being moral means more to me than being social.

I feel that an english department should try to raise the level of morality, not lower it. I feel that we should read good, thoughtful literature -not psychological trash. (This complaint is not against you. I had the same complaint last year.) Instead of assigning a little bit of all types of literature school has given me 75% trash and 25% shakespeare.

To this the teacher replied:

Did you ever consider how much violence and "immorality" is depicted in Shakespeare?

Most English programs in secondary school study historical or thematic categories in literature. Literature teachers seem to emphasize how the literature is surrounded by the world of social actions and the world of individual thought and ideas (Frye, 1973). Most questions asked by teachers emphasize the sociological and psychological aspects of the story. Before reading a selection students are frequently asked to focus on vocabulary words, identify the type of person who they consider a hero or villain, and consider a focused type of friendship or social setting. Questions and tasks to be done during the reading frequently require active response to help the student focus attention on crucial aspects of the selection - again most often from a psychological perspective. Questions such as why did people react that way, what do you think they will do, and what is the author's perception of (x), all typically force the student into psychological analysis. Even the exercises required of the student after reading the selection which are viewed as moving toward synthesis, analysis, and evaluation, typically focus on social science aspects rather than mathematical or

physics-related ideas. Students are asked to describe the cultures from which characters in the story came, to think of other interactions which might have brought the story to closure, or to analyze plot, characterization, theme or symbolism.

The very common focus of literature classes on the negative social interactions of society runs counter to the interests of many young men and women who wish to focus their free inquiry time on physics, technological innovation, mathematics and philosophy. The psycho-social literature selections chosen by teachers and the required activities which surround the selections are found trivial and even offensive by this group of students. It will be noted that they are willing to read great classics such as Shakespeare and Chaucer which contain violence, but which have internal structure which is richly interwoven. These students are even willing to memorize rather extensive passages of old English as a counterpoint to modern linguistic style. They do not dislike literature, but almost without exception, they find great displeasure with the way literature is presented in typical English classes. Literature instruction does not meet the needs of these "spatially gifted readers."

The Other Young Man

Being a brilliant and willful individual, this young man frequently found himself outside the expectations of society. Because he knew how to work mathematics problems, he frequently didn't bother to finish them. The remainder of the proof was "too obvious" to be of enough interest to complete. Never-the-less, this student was willing to complete written compositions

because they offered more complexity to deal with than simple equations. (This student is currently examining the mathematical--topological properties of space in a PhD physics program - a concept which apparently has sufficient complexity for him.)

As a junior in high school he grew tired of the course offerings available, and abruptly left school at the end of his junior year. Since he had completed all of the graduation requirements anyway (including advanced calculus, physics, chemistry, biology, history, three years of foreign language, and language arts), he was quietly given a High School diploma. The next year he enrolled in the local college while trying to decide "where he should study" - that is, to which universities he should apply for a regular college education. (As it turned out he was accepted by many of the Ivy League colleges, was awarded a large scholarship for academic excellence, and graduated after three years of "challenging" courses by simply passing competency exams. He majored in theoretical physics.)

The first term at the local college was found boring. The next term found him demanding the right to take graduate level courses in Russian history, history, and philosophy. He also continued with senior level math and physics). Comments in a letter to his friend reveal a great deal about this young man.

> My classes this term are the best I've had at the U. In fact, the worst class I'm taking is the honors class in war and it was supposed to have been the best. I think that points out the superiority of graduate classes.
>
> Still, back at the war class, we have endless discussions (primarily because none of the textbooks we were supposed to read came in on time -one arrived yesterday). The discussions are frustrating because of the massive cloudbank

that occupies the minds of most of the class members and the professor. For some reason, God knows what, these people are hung upon the "a priori" assumption that war is bad while at the same time they are trying to argue about how wars begin and how people behave in them. Their assumption is so overriding that it seems they can have no conception of the possibility that some people in war act on the assumption that war is not bad. Consequently, we are endlessly tangling ourselves in what appears to be contradictory behavior.

In support of our class, I must say, however, that there are very few sheep. I must say I was quite surprised at the complete blanket rejection that is given to many ideas brought up in class. (Of course, I rank high among those continually rejected.) It has reached a point where when I begin to make a point, it seems like I'm talking to a wall- a wall that is continually being buttressed from the other side at that. When I realized this my interest in the class greatly increased.

I can make the most solid of walls listen, so now it is a challenge for me to break down this psychological wall constructed against outside influence. My previous attitude was indifference; I think I will take a more out-going posture in the future. This wall is significant in that it shows there are still people who stick to their own beliefs and who have the strength to hold them. Alas, as with most things of beauty, one has to test oneself against it by trying to tear it down.

There is a whole philosophy about "the wall" that I might tell you about some time. I'm being presumptious, of course, but I think I could tell you some interesting new things about it.

About this time (just after his seventeenth birthday) he decided he needed a job. Can you imagine what type of job he landed? Did you ever wonder who writes those masters and doctoral thesis on the "black market?" His letter commented:

The big news of mine is that I have gotten a job of sorts. My job is well suited towards my demonstrated abilities. My demonstrated abilities being, of course, getting good grades. To end the suspense, I will tell you what I am doing. Quite bluntly, I write research papers for a company at $3 a page. I made nearly $50 in my first week (last week, by the way). These papers are on almost every conceivable subject. It appears that I am participating in the academic black market by writing these papers. (Exciting, isn't it...) Ethically, I am unbothered though others in my place might be. To me, I'm doing what I've always wanted to do: be paid to study.

Younger Children

What kinds of problems are encountered by this type of child in the elementary years? One child had a frequently encountered problem. The local library sponsored a "Summer Reading" program. Students were to read twelve books to be awarded a gold seal for reading excellence. This child (a boy) enjoyed the opportunity for summer reading very much. He would go to the library about once a week to check out fifteen to twenty books. He discussed his reading with the Librarian and obtained her signature for his completed selections. By the end of the summer he had registered over fifty selections with the Librarian. He was reading above his grade level and enjoying it immensely. He was in the third grade and was attracted not only to the Danny Dunn series, but to Tom Swift, Doc Savage, and Lucky Starr. At the end of the summer he was informed that he did not qualify for the reading award. He had read in only one area of literature and the certificate required that he read in four areas (such as fiction, biography, poetry, fantasy and mystery). The child refused to read in the other areas. He explained to the Librarian that if this was indeed to be a program for pleasure reading then it should allow people to read as they chose. The child's name was not posted on the wall of the library as one of the able readers of the community who had participated in the summer reading program - although he had been reading nearly a book a day. In the end, the boy was quietly given his gold star to take home, however he was made to feel that he had something "bad." It is no wonder that this student refused to fill out book cards indicating his

recreational reading for his classroom teacher the following year.

Response to a Creativity Lecture

A few years ago the Cheveron traveling exhibit on Creativity provided a speaker for an assembly in our school for "gifted" children. The presentation was made in the lunchroom. Children in the audience were ages 7 to 14. As a teacher I dutifully positioned myself at a table filled with wiggly little boys. The speaker presented a number of projects in which the rather large audience (about 80 students) participated. I remember one project in which IBM cards were distributed to all students. The students were asked to create something that they might find useful to have on the moon. They could fold but not tear the cards. For another task they could tear the cards to produce a useful object. After a while the speaker asked the students to put the cards down so she could go on to the next activity. Some of the boys near me continued to mutilate their cards in a purposeful manner. The speaker began explaining how several great artists, scientists and thinkers of past eras had refused to conform to the expectations of their day. They had gone beyond the guidelines given to them by school and the scientific community. She had to stop her speech several times to ask wiggly students to put down their cards and listen to her as the time period for working with cards was over! Spatial creativity?

My most vivid memory of the presentation was when the speaker told two stories. The first story was told in good "story-telling" form. Most of the children listened attentively. The little boys at my table were not very interested. They

quietly went "bruuuumm bruuummm" with their pencils as they moved them like cars around the table. I noticed that the students near me consisted primarily of those who had been identified in my research as having spatial-transformational ability. My next awareness was that the students near me had begun to pay attention to the speaker. Several of them were standing up - craning their necks to see what the speaker was holding. At about this time I noticed many students in the rest of the audience quietly drop their chin on their hands or even put their heads down. A complete reversal of attention was being exhibited by students in the room. Those who had been attentive were slumping in their chairs. Those who had been "off in an imaginary world" were actively attentive. What had happened?

The speaker was holding up geometric shapes which were about 18" square. There were three shapes, a square, a triangle and a circle. She was positioning the shapes in a sequence of arrays indicating the stages in the development of the story. She challenged the students to recognize the story she was portraying. The previously disinterested "spatially gifted" students were obviously having a grand time trying to decode the events. Finally someone identified the story: Millions of Cats by Wanda Gag.

We have seen that the problems of "gifted readers" who are also "spatially gifted" may stem not so much from their original lack of interest in language arts as from the difference between these students and their teachers. "Spatially Gifted" students delight in intertwining spatial, mathematical, and linguistic ideas. Teachers are not currently prepared to deal with these.

SUGGESTIONS FOR TEACHING

Literature Selections for Gifted Readers Who Are Also Spatially Gifted

Where Are They Headed?

The literature rarely reports personal profiles of adolescent or young adult "gifted readers" who are success stories. Most of our data on successful "gifted" individuals is retrospective. Most of the adolescent case studies are developed by counselors who wish to communicate problems of the non-successful "gifted" student. This lack of real-life data causes most curriculum projects to be directed toward an imagined or idealized "gifted" reader.

We are of the opinion that case studies of adolescent experiences of highly successful young adults will be a useful addition to the "curriculum and instruction" literature. Accordingly, these suggestions for teaching are introduced by quoting the perspective of a young adult "gifted reader" who demonstrates extrodinary "spatial" capabilities. The question of interest is how to construct appropriate instructional tasks for the secondary school experience of this type of student.

In his personal essay for the Rhodes Scholarship Finals this student made the following statements.

> During fifth grade I acquired my first intellectual activity, one that has stayed with me to the present; the reading of science fiction. At that time I discovered a series of books entitled Tom Swift. I was fascinated by this series because each book was built around a clever idea, usually embodied in some sort of machine. In the course of resolving the plot the machine was used in some highly creative and unexpected way. These and other books stimulated in my mind innumerable questions of "What if...?"
> I would dream my way from one creative solution to another. To this day I retain my interest and delight in "What if...?" types of questions, and I feverently hope I always will, for I feel it is one of my best and most important personal characteristics.

However, as I have matured I have discovered that there are many, many things in this world that are interesting in addition to machines. By the end of High School I had developed strong interest in math (all forms but especially geometry), physics, computers, linguistics, and philosophy, and had spent a great deal of time discussing aspects of these topics with friends...

For a variety of reasons I decided to study "science" first, specifically physics. To this end I came to Caltech. Here I have energetically pursued my interests in physics, establishing, I feel, a strong enough foundation that I can effectively work in any part of physics without more formal class instruction....

Caltech's courses in market theory and game theory are excellent. They prompted me to toy with "ideal" economic systems and with ways to improve the existing systems...In addition, during term breaks and summer vacations I spent a great deal of time considering topics in education, such as, how do people learn, how should one teach, how does one develop a personal ethic, how does one develop logic skills and creativity, and especially how can one help others develop these qualities and skills...

At this point one might well wonder what the point of all this studying is, what is it leading to? A simple and straight forward reason is that I enjoy learning. I enjoy taking diverse topics, intertwining them, synthesizing new ideas from them and making "What if...?" questions out of them...

Pragmatically, such a broad range of interests is necessary in order to prepare one to deal with the world as it is becoming. One needs a strong science background to deal efectively with the technology we have created. One needs to have spent a good deal of time contemplating moral and ethical questions so that one can wisely decide how to use the technology we have created. Without both one will not be able to deal effectively with the problems that our technology will create...

Finally, I believe that an ever questioning, ever learning approach to life will help me develop the compassion and wisdom that I have seen and admired in such a man as Jacob Bronowski. It will help me develop the compassion to understand to some extent those people around me, how they feel, their needs and wants. It will help me develop the wisdom to see the vast interconnectedness of the world so that I can understand the consequences of my actions and thus be able to help others without damaging them, both on a personal level and at the level of guiding (a small part) of future human development.

On a personal essay for application to graduate schools written about the same time this individual wrote:

How do ALL things work and why do they work in whatever way they do?

This question is the cornerstone upon which I have, am, and will try to build my life. Unfortunately, there does not seem to be enough time in my life to deal explicitly with the how's and why's of ALL things in the way I would like to. Hence, I - sigh - have to be happy with merely studying those things that explain the how's and why's of as much as possible, as efficently as possible. Now, making the most general, most fundamental statements about things seems to be the province of Physics. Hence I have, am, and will study Physics....

My current interest is the applicaton of the aethods of differential geoaetry to basic probleas in the areas of general relativity theory and/or high energy-density theory. In particular I wish to use this forsalisa to clarify the basic problea in these fields and as a guide to effective aethods of solution. (eg. local and globe transforaational syaaetries of the theories, breaking of those syaaetries and geoaetrical interpretation of what's happening, Lie-Backlund transforaation techniques, Phase space analysis: limiting behavior at large tiaes)

I aa also interested in using other techniques (eigen-function expansions, asyatotic expansions, w.k.b., weiner hopf, etc) in the above and following fields; theraodynaaics, statistical aechanics, phase transitions, low teap, solid state (particularly quantua electronics and quantua optics), plasaa physics (fusion and the problea of auon catalysis), and anything else.

The particulars of this are coapletely open. My past experiences have been priaarily with scattering type experiaents, either nuclear or high energy... I helped Dr... perfora light nuclei fusion experiaents...I worked with Dr...in the Tasso group at Petra studying an e e colliding beaa storage ring at the Deutches Electron Syncrotron (DESY) in Haaburg, Geraany...

Several instructional issues arise from a review of these comments. Not all "gifted readers" will become literature majors, writers, or social scientists. The existing curricular focus on these subject matter areas needs to be broadened to include the omnivorous interests of the "spatially gifted reader." Secondly, at least with this type of student, a consideration of morality and humanity stems from an interest in physics. Physics first, humanistic analysis later. Is it possible to find instructional tasks which will allow this kind of mind the freedom to explore mechanical implicatons presented in literature during those years when this is the all-consuming passion?

In fact, we have no choice. Either we find instructional tasks compatible with student interests or we lose the student. These students are resolute in their interests and will not conform to our current curricular expectations which require analysis of morality and humanity instead of an analysis of physical laws. They may (or may not) make it through our existing

school system, but they will cease to communicate with us unless we begin to recognize their needs.

Literature teachers need to recognize that these students are growing in the direction which fulfills their highest purpose in teaching. This type of student is becoming a moral and humane individual. We need to recognize the timing of cognitive interests in "spatially gifted readers." Most of the "spatially gifted" with whom I have worked express an overriding desire to contemplate three-dimensional spatial settings between the ages of about ten and sixteen. By age seventeen most of them have expressed an interest in philosophy. Their contribution to philosophy class is in sharp contrast to those students who have a background only in literature and history. The "spatially gifted" bring a structural analysis to the logic of a philosophic discussion and a structural analysis to the evaluation of a written composition. Although these students appeared (to some of their literature teachers) to be lagging in their analytic abilities in grades 5 - 11, suddenly, in grade 12 they demonstrated logical insight which surpassed the other students. We want this kind of adult. How can we help them while they are students?

Selections To Start With

A literature selection suited to this type of developing interest must contain correct and believable physics, and yet it must facilitate "What if's..." about the physical phenomena. Sociological and psychological aspects of the setting must be only peripheral elements in the story. "Feeling Tone", so

frequently uppermost in a literature teacher's mind, must not be the focus of analysis questions.

The type of Science Fiction story advocated here is one which maintains conventional physics in all but one parameter. Twisting one law of physics with respect to all of the conventional laws allows the student to contemplate "What If..." in terms of logical consequences. Please notice we are not advocating the type of literature called Science Fiction which treats the laws of physics as some magical or metaphysical construct where all or most of the laws of conventional physics are either violated, ignored, or "time-warped."

An excellent collection of stories edited by Asimov is entitled Where Do We Go From Here. Not all of the selections in this volume meet our criteria, but many do. The selection which has been most consistently successful is The Big Bounce by Walter Tevis. It is about a ball so elastic that once it started bouncing (how does this accidently happen?), each bounce would be higher than the last. The special joy of the story is the developing awareness that the process violates the second law of thermodynamics - revealed in the surprise ending where, finally, the ball's heat was all used up as energy for bouncing, so it froze and shattered before it could do any damage.

In the process of editing the book, Asimov wrote a short commentary at the end of each story, concerning the science concept violated and the scientific principles against which the action was set. He also posed questions at the end of each commentary which are worthy of a literature teacher's

consideration. They require a student to write as clear and well composed an answer as any "humanistic" queston the teacher might assign. They require analysis, synthesis and evaluation which go well beyond the information presented in the story - in keeping with the goals and objectives of curriculum tasks for the "gifted." Most importantly, the questions do not violate the interests of this particular type of student. They facilitate thought about topics of interest to this student.

The questions posed by Asimov at the end of The Big Bounce are:

> 1. What is the stand of the U.S. Patent Office on "perpetual motion" machines? All of these, incidentally, break either the first or the second laws of thermodynamics. Why?
>
> 2. The ocean has vast quantities of heat in it. Even a polar ocean does. Why do ocean vessels have to burn fuel? Why can't they just use the heat of the ocean water over which they pass?
>
> 3. In view of the first law of thermodynamics, where does the tremendous energy radiated by the Sun and all the other stars come from?
>
> 4. Look up the history of some perpetual motion machines designed in the past. What was the "catch" in each case? Why wouldn't they work? Were some of them outright hoaxes?
>
> 5. The laws of thermodynamics are based on the general experience of scientists. They have never observed the laws to be broken. Scientists, however, merely observe their own section of the universe and their own general type of environment. What about outer space ten billion light-years away? What about the center of the Sun? How sure can we be that scientific laws are the same everywhere under all conditions?
>
> 6. Suppose a scientist discovered some easily produced phenomenon which seemed to defy either the first or second law of thermodynamics. Should he assume at once there was some mistake and forget the whole thing? Should he instantly proclaim the phenomenon and declare the laws broken? What would you do?

Does a literature teacher have to have an extensive knowledge of science and mathematics in order to grade these questions. I think not. These questions are probably general enough in nature to be graded by most literature teachers.

Another story that is very popular with the "spatially gifted" comes from the same collection edited by Asimov. The story is entitled The Holes Around Mars and is by Jerome Bixby. After detecting strange gouges in rocks, leaves, and hills which all seem to line up, the spaceship crew discovers (in an amusing manner) that the planet has a moon traveling just four feet above the ground. Of course such a moon would have to travel at impressive speed to keep at that altitude. Since the other moons of Mars are named Deimos and Phobos, the newly discovered moon is named "Bottomos."

After pointing out the scientific flaws in the story in his short commentary, Asimov posed these questions:

1. What is the orbital velocity of the two known Martian satellites? If you divide the escape velocity from the Martian surface by the square root of two you would obtain the orbital velocity for a satellite revolving in a circular orbit in the neighborhood of the Martian surface. How much is that in miles per hour? If the satellite were of ordinary granite, what would its kinetic energy be in comparison with that of a .45 bullet shot out of a revolver?

2. If the third satellite were neutronium, how much would it weigh? What would be its kinetic energy at the orbital velocity?

3. Our explorers in The Holes Around Mars find that the holes are in a straight line; that is, if you sight through a hole in one place you would see another hole in another place far away. But could you? Is the third satellite traveling in a true straight line or is it following the curvature of the Martian surface? How much does the Martian surface curve; that is, in the space of one mile, how far does the Martian surface drop? Calculate how far apart two holes must be so that when sighting through one you can no longer see the other.

4. According to the story, it would seem that the third satellite follows precisely the same path each time it circles the planet. Yet if the orbit were at an angle to the Martian equator, it would follow a different path each time around, for Mars will have rotated part-way during the time of one orbit. What would the orbit look like on a flat map of the Martian surface?

5. If the third satellite were following a path exactly along the Martian equator, the rotaton of the planet wouldn't matter and the little satellite would follow its own track each rotation. (Why?) Is it likely, though, that its orbit would be lined up exactly with the Martian equator? What about the orbits of Phobos and Deimos in this respect? Suppose the third satellite's orbit varied from the line of the equator so slightly that it moved four inches north of the equator at one extreme of its orbit and four inches south at another. What would that do to the holes?

Although some of the stories in Asimov's book Where Do We Go From Here were not recieved well by "spatially gifted" students, most of them were. A Subway Names Mobius by A. J. Deutch is a delightful story which can be followed by having the students actually construct Mobius strips out of paper and tape. This causes one to contemplate the way two-dimensions can warp through three-dimensions.

And so we have the challenge, can instructional methods be developed which will maintain the interest of "gifted readers" who are also "spatially gifted?" Clearly, the existing language arts instructional methods are good for most students. We have produced a literate populace by-and-large. It is likely that short term changes in national competency test scores reflect attitudinal changes in society more than inappropriate instructional methods. Our concern is that a small but rather important group of students seems to have been overlooked in our development of instructional alternatives. It is hoped that by understanding the cognitive style and developmental time-frame of this group of students educators will be able to develop appropriate material for them.

The following list of books which have been collected by "spatially gifted" students should provide a source of instructional material around which "reading guides" can be developed.

READING PREFERENCES OF THE SPATIALLY GIFTED
Science Through Science Fiction

It appears that science "nuts" and literature "nuts" may view science fiction stories very differently, however both value the contributions of Isaac Asimov. Asimov believes good science can be examined through science fiction.

> I have long maintained that science fiction has potential as an inspiring and useful teaching device. (Asimov)
>
> Anyone who wishes can read them for themselves alone, no need to make a conscious effort to learn from them. (Asimov)
>
> It is sometimes said that a good science fiction writer makes one assumption - even an impossible one - to start his story and then, no more. (Asimov)

Really, the question is, what do we mean by science fiction? Do we mean fiction written with a few terms from science? Do we mean good science written with one fictional twist of a science concept?

A student once said to me: "science fiction allows me to consider the ramifications of an impossibility without being told that I am wrong before I even start to think."

Mental Imagery: as Real as Actual Experience

An article in Scientific American by Harry Jerrison entitled Paleoneurology and the Evolution of Mind (January, 1976) made some remarks which seem quite fitting for an introduction to this reading list.

Language is a side effect in the construction of reality.

I am proposing here that the role of language in communication first evolved as a side effect of its basic role in the construction of reality. The fact that communication is so central to our present view of language does not affect the argument. It is, in fact, theoretically elegant to explain the evolution of an important novel adaptation in a species by relating it to the conservation of earlier patterns of adaptation.

Language is an expression of mental imagery.

We can think of language as being merely an expression of another neural contribution to the construction of mental imagery, analogous to the contribution of the encephalized sensory systems and their association systems.

Telling Stories Creates Mental Images.

We need language more to tell stories than to direct actions. In the telling we create mental images in our listeners that might normally be produced only by the memory of events as recorded and integrated by the sensory and perceptual systems of the brain.

Mental images are as real as experiences.

Mental images should be as real, in a fundamental sense, as the immediately experienced real world. Both are constructions of the brain, although it is appropriate to encode them in order to distinguish image from reality.

We share another's consciousness.

The role of language in human communication is special because we have the vocal and manual apparatus to create spoken and written language. In hearing or reading another's words we literally share another's consciousness, and it is that familiar use of language that is unique to man. The point, however, is that it was necessary to have a brain that created the kind of consciousness communicated by the motor mechanisms of language.

Intelligence is the capacity to integrate sense perception into information about the space and time of objects.

If one defines intelligence as the capacity to construct perceptual worlds in which sensory information from various modalities is integrated as information about objects in space and time, the evolution of intelligence is most evident in mammals. ...The trend culminated in man, and we know it as the capacity for imagery, for language and for culture.

To Examine The Space-Time Physics of Impossible Machines

The Reading Curriculum and Instruction community is quite concerned with imagination and fresh perspective. What provides creative technological experiences other than direct sensory input from physical action? Science fiction! These readings code hypothetical technological and scientific events in mental imagery which can be examined and critically considered by the student. When a child imagines a technological situation, the realities of the known physical world usually tell him that the idea is not possible. Formal reasoning requires "if-then" thinking. When the "if" is dampened by reality, the possible "then's" are rarely considered in serious detail. Certain types of science fiction provide a vehicle for considering "if's" in great detail in a manner similar to that produced through experience. Such reading thus provides a "safe" way to try out extravagent scientific ideas and fully explore the consequences. The child is thus enabled to (for example) logically argue about n-dimensional reality and curved space at infinity.

Is there a correlation between devotees of science (youthful zealots as Terman called them) and a definable body of science fiction indulged in? Our data strongly suggests that there is. Collection of reading selections regularly mentioned in "overheard" conversations between "spatially gifted readers" over a period of sixteen years produced the following list of books and stories. No claim is made concerning the literary merit of the works except for the fact that they were read and prized by "spatially gifted readers."

Science Fiction Valued by Spatially Gifted Readers

part of
A sixteen year collection of
Titles and authors provided by students
no publishers were available

Anderson, Paul	War of the Wing-Man
	World Without Stars
	The High Crusade
Anderson, Chester & Kurland, Michael	Ten Years to Doomsday
Appleton, Victor,II	Tom Swift and His Flying Lab
	Tom Swift and HIs Jetmarine
	Tom Swift and His Rocket Ship
	Tom Swift and His Giant Robot
	Tom Swift and His Atomic Earth Blaster
	Tom Swift and His Outpost in Space
	Tom Swift and His Diving Seacopter
	Tom Swift in the Caves of Nuclear Fire
	Tom Swift on the Phantom Satellite
	Tom Swift and His Ultrasonic Cycloplane
	Tom Swift and His Deep-Sea Hydrodome
	Tom Swift in the Race to the Moon
	Tom Swift and His Space Solartron
	Tom Swift and His Electronic Retoscope
	Tom Swift and His Spectromarine Selector
	Tom Swift and the Cosmic Astronauts
	Tom Swift and the Visitor from Planet X
	Tom Swift and the Electronic Hydrolung
	Tom Swift and His Triphibian Atomicar
	Tom Swift and His Megascope Space Prober
	Tom Swift and the Asteroid Pirates
	Tom Swift and His Repelatron Skyway
	Tom Swift and His Aquatomic Tracker
	Tom Swift and his 3-D Telejector
	Tom Swift and His Polar-Ray Dynasphere
	Tom Swift and His Sonic Boom Trap
	Tom Swift and His Subocean Geotron
	Tom Swift and the Mystery Comet
	Tom Swift and the Captive Planetoid
Anthony, Piers	Macroscope
Asimov, Isaac.	Lucky Star: David Star Space Ranger
	Lucky Star The Big Sun of Mercury
	Lucky Star: The Rings of Satrun
	Lucky Star: The Moons of Jupiter
	The Gods Themselves
	The Stars Like Dust
	The Caves of Steel
	Fastastic Voyage
	The Foundation Series

	The Naked Sun
	The Best of Isaac Asimov
	The Rest of the Robots
Beatty	Mathew Looney series
Benford, Greg	Deeper Than the Darkness
Biemiller	The Hydronauts
	Follow the Whales
	Escape from the Crater
Blish	Mission to the Heart Stars
	The Star Dwellers
	The Vanished Jet
	Cities in Flight
Bova	The Dueling Machine
	Star Watch Man
	The Star Conquerers
	Exiled From Earth
	Flight of Exiles
	The Weather Makers
Boulle, Pierre	The Planet of the Apes
Bradbury, Ray	The Vintage Bradbury
Brown,Frederic	Rogue in Space
Brink	Andy Buckram's Tin Men
Brinkley	The Mad Scientists' Club
	The New Adventures of the Mad Scientists
Burn, Doris	Andrew Henry's Meadow
	The Summerfolk
Campbell, John	The Mightiest Machine
	Cloak of Aesir
	Analog 6
	The Ultimate Weapon
Chandler, A.	The Road to the Rim
Clark, A.L.	Dolphin Island
	A Fall of Moon Dust
	From the Ocean, From the Stars
	Earthlight
	Against the Fall of Night
	Childhood's End
Clement, Hal	Mission of Gravity
Conklin,	Giants Unleashed

Conway, Gerard	The Midnight Dancers
Cory, Howard	The Mind Monsters
Cummings, Ray	The Exile of Time
Davies, L.P.	Dimension A
Del Rey, Lester	The Runaway Robot Robot from Infinity Outpost of Jupiter Tunnel Through Time Attack From Atlantis Nerves
Dick, Phillip	The Unteleported Man
Dickson, Gordon	Secret Under Antartica Secret Under the Sea Tactics of Mostake The Alien Way Time to Teleport None But Man
Doyle, Arthur C.	The Lost World
Edwards, Norman	Invasion from 2500
Engdahl	Enchantress From the Stars The Star Shall Abide Beyond the Tomorrow Mountains The Far Side of Evil Journey Between Worlds
Oster, Alan Dean	Star Trek Dog
Fairman	The Forgetful Robot
Galouye, Daniel	Lords of the Psychon
Gilman	Starman of Ramada
Godwin, Tom	Beyond Another Sun
Grinnell, David	Edge of Time
Halacy	Return From Luna
Hamilton, Edmond	Battle for the Stars The Haunted Stars The Star Kings
Harrison	Worlds of Wonder
Herbert, Frank	Destination: Void

Heinlein	Between Planets Citizen of the Galaxy Farmer in the Sky Have Space Suit - Will Travel Red Planet Rocket Ship Galileo Rolling Stones Space Cadet Star Beast Starman Jones Tunnel in the Sky Podkayne of Mars The Moon is a Harsh Mistress Orphans of the Sky
High, Philip	The Time Mercenaries
Hoyle	October Fifth is too Late
Hubbard, L	Ole Doc Methuselah
Hughes	Iron Giant
Jakes, John	Time Gate
Jones	This Sunless World
Juster, Norton	The Phantom Tollbooth
Key	Forgotten Door
Knight	Beyond Tomorrow collection Dimensions Worlds To Come
Lampman	Rusty's Spaceship The Stegosaurus of Cricket Creek
L'Engle	Arm of the Starfish Wrinkle in Time
Lightner	The Space Plague Space Olympics Rock of Three Planets Get out of my World
Lesser	Spaceman, Go Home Stadium Beyond the Stars
Maddock, Larry	The Golden Goddess Gambit
Mason, Douglas	Eight Against Utopia
MacGregor	Miss Pickerell series

McCaffrey, A.	Dinosaur Planet
McDaniel, DAvid	The Arsenal Out of Time
Moorcock, Michael	The City of the Beast The Master of the Pit
Norton	Cat's eye Exiles of the Stars Moon of Three Rings The Zero Stone Star Rangers Quest Cross Time Forerunner Foray Lord of thunder Starman's Son Postmarked the Stars Judgement on Janus Victory on Janus Operation Time Search Ice Crown Star Born Uncharted Stars Storm Over Warlock Star Guard Merlin's Mirror The Defiant Agent Star Gate Galactic Derelict The Time Traders Key Out of Time The Beast Master The Sioux Spaceman
Norse	PSI High and others The Universe Between Star Surgeon Rocket to Limbo Raiders from the Rings
Obruchev	Plutonia
Petja, Emil	The Star Mill
Poh, Fred	Alternating Currents Wolfbane The Wonder Effect The Reefs of Space Starchild
Rockwell, Carey	Stand By for Mars
Richmond, W. & L.	The Lost Millennium
Robeson	Doc Savage series

Schealer	Zip Zip and his Flying Saucer
Sheckley, Robert	Store of Infinity
Scheer & Ernsting Mahr, Darlton, Brand	Perry Rodan: Enterprise Stardust Perry Rodan: The Radiant Dome Perry Rodan: Galactic Alarm Perry Rodan: Invasion From Space Perry Rodan: The Vega Sector Perry Rodan: The Secret of the Time Vault Perry Rodan: Fortress of the Six Moons Perry Rodan: The Galactic Riddle Perry Rodan: Quest Through Space and Time Perry Rodan: The Ghosts of Gol Perry Rodan: The Planet of the Dying Sun Perry Rodan: The Rebels of Tuglan Perry Rodan: Venus in Danger Perry Rodan: The Venus Trap Perry Rodan: Menace of the Mutant Master Perry Rodan: Mutants vs. Mutants Perry Rodan: The Thrall of Hypno Perry Rodan: The Cosmic Decoy Perry Rodan: Fleet of the Springers Perry Rodan: Peril on Ice Planet Perry Rodan: Infinity Flight Perry Rodan: Snowman in Flames Perry Rodan: Cosmic Traitor Perry Rodan: Planet of the Gods Perry Rodan: The Plague of Oblivion Perry Rodan: A World Gone Mad Perry Rodan: To Arkon! Perry Rodan: Realm of the Tri-Planets Perry Rodan: Challenge of the Unknown Perry Rodan: The Giant's Partner Perry Rodan: SOS: Spaceship Titan Perry Rodan: Beware the Microbots Perry Rodan: Man and Monster Perry Rodan: Epidemic Center: Aralon Perry Rodan: Project: Earthslave Perry Rodan: The Silence of Gom Perry Rodan: Red Eve of Betelgeuse Perry Rodan: The Earth Dies Perry Rodan: Time's Lonely One Perry Rodan: Life Hunt Perry Rodan: The Pseudo One Perry Rodan: Unknown Sector: Milky Way Perry Rodan: Again Atlan Perry Rodan: Shadow of the Mutant Master Perry Rodan: The Dead Live Perry Rodan: Solar Assassins Perry Rodan: Attack from the Unseen Perry Rodan: Return from the Void Perry Rodan: Fortress Atlantis Perry Rodan: Spybot

Perry Rodan: *The Blue Dwarfs*
Perry Rodan: Micro-Techs
Perry Rodan: Prisoner of Time
Perry Rodan: A Touch of Eternity
Perry Rodan: The Guardians
Perry Rodan: Interlude on Siliko
Perry Rodan: Dimension Search
Perry Rodan: Death Waits in Semispace
Perry Rodan: Last Days of Atlantis
Perry Rodan: The Tigris Leaps
Perry Rodan: The Ambassadors From Aurigel
Perry Rodan: Renegades of the Future
Perry Rodan: The Horror
Perry Rodan: Crimson Universe
Perry Rodan: Under the Stars of Druufon
Perry Rodan: The Bonds Of Eternity
Perry Rodan: Thora's Sacrafice
Perry Rodan: The Atom Hell of Grautier
Perry Rodan: Caves of the Druufs
Perry Rodan: Spaceship of the Ancestors
Perry Rodan: Checkmate Universe
Perry Rodan: Planet Topide: Please Report
Perry Rodan: Recruits for Arkon
Perry Rodan: Conflict Center: Nautor
Perry Rodan: Power Key
Perry Rodan: The Sleepers
Perry Rodan: The Columbus Affair
Perry Rodan: Pucky's Greatest Hour
Perry Rodan: Atlan in Danger
Perry Rodan: Ernst Ellert Returns
Perry Rodan: Secret Mission: Moluk
Perry Rodan: Enemy in the Dark
Perry Rodan: Blazing Sun
Perry Rodan: The Starless Realm
Perry Rodan: The Mystery of the Auti
Perry Rodan: Power's Prize
Perry Rodan: Unleashed Powers
Perry Rodan: Friend to Mankind
Perry Rodan: The Target Star
Perry Rodan: Vagabond of Space
Perry Rodan: Action: Division 3
Perry Rodan: The Plasma Master
Perry Rodan: Horn: Green
Perry Rodan: Phantom Fleet
Perry Rodan: The Idol from Passa
Perry Rodan: The Blue System
Perry Rodan: Desert of Death's Domain
Perry Rodan: Blockage Lepso
Perry Rodan: Spoor of the Anti's
Perry Rodan: False Front
Perry Rodan: The Man With Two Faces
Perry Rodan: Wonderflower of Utif
Perry Rodan: Caller From Eternity
Perry Rodan: The Emperor and the Monster
Perry Rodan: Duel Under the Double Sun

	Perry Rodan: The Stolen Spacefleet
	Perry Rodan: Sgt. Robot
	Perry Rodan: The Seeds of Rain
	Perry Rodan: Planet Mechanica
	Perry Rodan: Heritage of the Lizard People
	Perry Rodan: Death's Demand
	Perry Rodan: Sabateurs in A-1
	Perry Rodan: Psycho Duel
	Perry Rodan: Savior of the Empire
	Perry Rodan: The Shadow's Attack
	Perry Rodan: In The Center of the Galaxy
	Perry Rodan: Between the Galaxies
	Perry Rodan: Killers From Hyperspace
	Perry Rodan: Atom Fire on Mechanica
	Perry Rodan: Volunteers for Frago
	Perry Rodan: Fortress in Time
	Perry Rodan: The Sinister Power
	Perry Rodan: Robots, Biomes, and Mutants
	Perry Rodan: The Guns of Everblack
	Perry Rodan: Sentinels of Solitude
	Perry Rodan: The Beast Below
	Perry Rodan: Blitzkrieg Galactica
	Perry Rodan: Peril Unlimited
	Perry Rodan: World Without Mercy
	Perry Rodan: Deadmen Shouldn't Die
	Perry Rodan: Station of the Invisibles
	Perry Rodan: Agents of Destruction
	Perry Rodan: Humans Keep Out!
	Perry Rodan: The Robot Invitation
	Perry Rodan: Starmen
Silverberg	Gate of Worlds
	Revolt on Alpha C
	Science Fiction Bestiary
	Starman's Quest
	Time of the Great Freeze
	Worlds of Maybe collection
	Conquerors from the Darkness
Simak	City
Slobodkin	Space Ship Under the Apple Tree
	Space Ship Returns to the Apple Tree
Smith, E.E. "Doc"	Tri-Planetary
	First Lensman
	Galactic Patrol
	Grey Lensman
	Second Stage Lensman
	Children of the Lens
	Masters of the Vortex
	The Skylark of Space
	Skylark Three
	Skylark of Valeron
	Skylark Dusuesne

	Spacehounds of IPC
	The Galaxy Primes
	Masters of Space
	Imperial Stars
Spinard, Norman	The Solarians
Sutton	Three Seated Space Ship
	Lord of the Stars
Todd	Space Cat
Turner, Gerry	Stranger from the Depths
Vance, Jack	The Killing Machine
Verne	Twenty thousand Leagues Under the Sea
	Journey to the Center of the Earth
Vogt, A. E. Van	Destination: Universe
	Future Glitter
	Quest for the Future
	The Silkie
	The Voyage of the Space Beagle
	Empire of the Atom
	The Weapon Makers
	The Weapon Shops of Ishir
Walters	Blast of A0300
	Destination Mars
	Expedition Venus
	First Contact
	First on the Moon
	Menace from the Moon
	Mohole Menace
	Mission to Mercury
	Neptune One is Missing
	Outpost on the Moon
Well, H	Star-Begotten
Werstein, Irving	Man Against the Elements
Widney	Elevator to the Moon
Williams	Danny Dunn series
Williamson, Jack	Bright New Universe
	The Cometeers
	Seetee Ship
	Trapped in Space
Wylie, Philip	When Worlds Collide
	After Worlds Collide

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